

A REVIEW OF THE LANCELETS, HAG-FISHES, AND LAMPREYS OF JAPAN, WITH A DESCRIPTION OF TWO NEW SPECIES.

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In the present paper is given an account of the *Leptocardii* and *Marsipobranchii*, lancelets, hag-fishes, and lampreys, known to inhabit the waters of Japan. It is based on material collected by the writers in Japan, in the summer of 1900, under the auspices of the Hopkins Laboratory of Stanford University. Series of the species named are deposited in the U. S. National Museum.

Class LEPTOCARDII.

THE LANCELETS.

Skeleton membrano-cartilaginous. Notochord persistent and extending to the anterior end of the head, inclosed in a membranous sheath as is the cord-like nervous axis above it. Heart a longitudinal tubular vessel which gives off branchial vessels which unite in an aorta; end of the nervous axis not dilated into a brain and not surrounded by a protective capsule, or skull. Blood colorless. Respiratory cavity confluent with the cavity of the abdomen; gill slits in great number, the water being expelled through an abdominal pore in front of the vent. Jaws none; the mouth a longitudinal fissure, with cirri on each side. Body lanceolate in form, more or less fish-like, and not enveloped in a tunic. Dorsal fin present, low; anal fin usually more or less developed.

Small marine animals, highly interesting to the zoologist as exhibiting the lowest degree of development of the vertebrate type. The class includes but the single order, *Amphiori* or *Cirrostomi*. (λεπτόσ, thin; καρδία, heart.)

## Order AMPHIOXI.

## THE CIRROSTOMES.

This order is equivalent to the family *Branchiostomida*. (ἄμφι, both; ὀξύς, sharp: *Cirrostromi* is from *cirrus*, a lock of hair; στόμα, mouth.)

## Family I. BRANCHIOSTOMIDÆ.

## THE LANCELETS.

Body elongate, lanceolate, compressed, naked, colorless; the fins represented by a low fold extending along the back, with usually a rudimentary fold below which passes by the vent to the abdominal pore. Mouth inferior, appearing as a longitudinal fissure, surrounded by conspicuous, rather stiff, cirri. Eye rudimentary. Liver reduced to a blind sac of the simple intestine. Small, translucent creatures found embedded in the sand on warm coasts throughout the world. The species are all very similar in appearance and habits, and the numbers of the muscular impressions furnish the only characters thus far known by which the species can be distinguished.

- a. Gonads (reproductive structures) present on both sides of the median line; anal fin present with traces of fin rays; no caudal process ..... BRANCHIOSTOMA, 1

## 1. BRANCHIOSTOMA Costa.

*Branchiostoma* COSTA, Cenni Zoologici Napol., 1834, p. 49 (*lumbricum*=*lancoletum*).  
*Amphioxus* YARRELL, British Fishes, 1836, p. 468 (*lancoletus*).

Lancelets with the gonads or reproductive structure present on both sides of the median line. Anal fin present, with traces of rays. Vertebral column not produced backward into a caudal process. Six or seven species recognized, found in the warm seas, usually buried in sand flats at no great depth. They are very tenacious of life, and will endure considerable mutilation. (βράγχια, gills; στόμα, mouth—the cirri about the mouth having been taken for gills by Costa.)

- a. Myocommata or muscular bands, 62 to 64.  
 b. Myocommata behind vent, 10 or 11, the formula usually  $37 + 16 + 11 = 64$  ..... NAKAGAWÆ, 1

## 1. BRANCHIOSTOMA NAKAGAWÆ Jordan &amp; Snyder, new species.

*Amphioxus* sp. ANDREWS, Zool. Anzeiger, 1895, p. 468, Goshi-no-ura, Amakusa, Buzen.  
*Amphioxus* sp. NAKAGAWA, Annot. Zool. Jap., 1, 1897, p. 127. Goshi-no-ura in Higo, Shikajima in Chikuzen.

Muscular bands,  $37 + 16 + 11 = 64$ . Usual length, 1 to 2 inches. Body relatively long, the tail short, the form rather stout. Sandy coasts of Japan, from Misaki southward to Kiusiu, our specimens from Misaki, presented by Dr. Mitsukuri. Others in Imperial University collected at Bungo by Dr. S. Matsubara, at Shikajima, by Dr. S. Hatta,

and at Misaki (Koájiro Bay) by Dr. H. Nakagawa. Dr. Ethan A. Andrews further records specimens from Goshinoura, Amakusa, and Buzen, in Kiusiu. Dr. Andrews, on specimens from Kiusiu, counts the muscular bands as  $37 + 16 + 11 = 64$ . On the type specimen from Misaki, very carefully counted for us, by Dr. Nakagawa, in the Imperial University, the following numbers were found in a specimen of 45.5 M.

Right side,  $37 + 16 - 10 = 63$ .

Left side,  $37 + 16 - 11 = 64$ .

The specimens from near Misaki were taken in Koájiro Bay, just north of Misaki, by the veteran collector, Kumakiehi Aoki, of Misaki.

The Japanese lancelet is very closely allied to *Branchiostoma belecheri* (Gray), (*Amphioxus belecheri* Gray),<sup>1</sup> from Bass Straits. According to Dr. Günther, the types of this species have the muscular bands  $37 + 14 + 13$ , the tail longer and the body shorter than in the Japanese form. It is possible that this difference is due simply to errors in counting. In view, however, of the almost entire difference in species in the shore fauna of Japan and that of Borneo, it seems to us best to regard the Japanese lancelet as a species distinct from *B. belecheri*. It needs comparison with no other.

Named for Dr. H. Nakagawa, of Tokyo, well known as an entomologist, in recognition of his excellent work on the present species.

## Class MARSIPOBRANCHII.

### THE MYZONTS.

Skeleton cartilaginous; the skull imperfectly developed, not separate from the vertebral column. No true jaws, no limbs, no shoulder girdle, no pelvic elements, no ribs. Gills in the form of fixed sacs, without branchial arches, six or more in number on each side. Nostril single, median. Mouth subinferior, suctorial, more or less circular. Heart without arterial bulb. Alimentary canal straight, simple, without caecal appendages, pancreas, or spleen. Generative outlet peritoneal. Vertical fins with feeble rays, usually continuous around the tail. Naked, eel-shaped animals, inhabiting cool waters, both fresh and salt. They undergo a metamorphosis, the young being often quite unlike the adult. (*μαρσίπιον*, pouch; *βράγχια*, gills.)

### ORDERS OF MARSIPOBRANCHII.

a. Nasal tube duct-like, with cartilaginous rings penetrating the palate; gill openings remote from the head, opening directly into the pharynx; no eyes.

*Hypocoeli*

aa. Nasal duct a blind sac, not penetrating the palate; gill openings close behind the head, communicating with a common branchial passage which opens directly into the pharynx; eyes well developed in the adult ..... *Hyperoartii*

<sup>1</sup> Proc. Zool. Soc. London, 1847, p. 35.

## Order HYPEROTRETI.

## THE HAGFISHES.

Nostril tube-like, with cartilaginous rings, penetrating the palate, its position at the extremity of the head, over the mouth; snout with eight barbels; mouth without lips; one median tooth on the palate and two comb-like series of teeth on the tongue. Branchial apertures at a great distance from the head; a series of mucous sacs along each side of the abdomen. Intestine without spiral valve. Eggs large, with a horny case provided with threads for adhesion. Marine lamprey-like animals, burrowing into the flesh of fishes, on which they feed. They may be referred to two families, differing mainly in the structure of the gill openings. (*ὄπερώα*, palate; *τροπήσις*, perforate.)

- a.* Branchial apertures six to fourteen on each side, each leading by a duct to a branchial sac.....*Eptatretidae*  
*aa.* Branchial apertures single on each side, from which diverge ducts to six branchial sacs.....*Myrinidae*

Family II. EPTATRETIDÆ.<sup>1</sup>

This family differs from the *Myrinidae* chiefly in the structure of the branchial apparatus, there being six to fourteen sacs on each side which receive water directly from the esophagus, as in *Myrine*, but the emptying ducts, instead of passing backward and downward to a common external opening, as in *Myrine*, pass directly through the wall of the body, so that there are as many external openings as there are gill sacs. Species few, inhabiting the colder parts of the Pacific, their habits similar to those of *Myrine glutinosa*.

The hagfish fastens itself usually on the gills or isthmus of large fishes, sometimes on the eyes, whence it works its way very rapidly into the inside of the body. It then devours all the flesh of the body without breaking the skin, so that the fish is left a living hulk of head, skin, and bones. It is especially destructive to fishes taken in gill nets. In gill nets, in summer, these empty shells of fishes are often obtained. When these are taken from the water, the hagfish scrambles out with great alacrity. It is thought that the hags enter the fishes after they are caught. A fish of 10 to 15 pounds weight will be devoured by them in a single night.

- a.* Gill openings six to eight on each side.....*Eptatretus*, 2

<sup>1</sup> We adopt the name *Eptatretus* instead of *Homœa* in deference to the argument of Professor Gill in the following paper.

2. EPTATRETUS Duméril.

*Eptatretus* (Duméril) CLOQUET, Dict. Sci. Nat. XV, 1819, p. 134 (*dombeyi* Duméril, not Lacépède).

*Homea* FLEMING, Philos. Zool., II, 1822, p. 374 (*banksi*).

*Les Héptatrémes* DUMÉRIL, Cuvier Règne Anim., 2d ed., II, 1829, p. 405 (*cirrhatus*).

*Heptatremes* (Duméril) M'MURTRIE, Anim. Kingdom, II, 1831, p. 298 (*cirrhatus*).

*Heptatrema* VOIGT, Das Thierreich, II, 1832, p. 529 (*cirrhatus*).

*Bdellostoma* MÜLLER, Abh. Ak. Wiss., Berlin, 1834 (*heptatrema*).

*Heptatremes* GRIFFITH, Animal Kingdom, X, 1834, p. 621 (*cirrhatus*).

This genus includes those *Eptatretidae* which have six to eight gill openings, thus differing from the West American genus, *Polistotrema*, which has from ten to twelve.

2. EPTATRETUS BURGERI (Girard).

NUTAUNAGI OR SLIME-EEL.

(Plate XXX.)

*Heptatema cirrhatum* SCHLEGEL, Fauna Japonica, Poiss., 1847, p. 310, pl. cxliii, Nagasaki (not *Petromyzon cirrhatus* Forster, from South Africa).

*Bdellostoma cirrhatum* ISHIKAWA, Cat., 1897, p. 63, Coast of Musashi (off Tokyo).

*Bdellostoma burgeri* GIRARD, Proc. Ac. Nat. Sci. Phil., 1854, p. 199, after Schlegel.

Snout 6 to  $6\frac{2}{3}$  in distance to first gill opening; gill area, with six openings, somewhat longer than snout; last gill opening on the left side double the size of the others; eye well developed; head, to gill opening,  $3\frac{1}{3}$  to  $3\frac{2}{3}$  in length of body; barbels, eight, the outer buccal barbels longest 2 to  $2\frac{2}{3}$  in snout; inner short and thick; nasal barbels long, much longer than labrum, the lower longest; teeth in upper row about 11 in number; tip of snout or labrum very broadly rounded; its width greater than length of upper barbel; dorsal and anal fins spreading widely on the tail; greatest breadth of tail with fins one and one-half times length of snout; tail, from vent.  $2\frac{1}{2}$  in head, from gill opening.

Color purplish or plum color, the belly a little dorsal, and anal darker, conspicuously edged with pale; a pale ridge about middle line of back; barbels pale; row of slime pores distinct along whole length of body.

Coasts of Japan, from Tokyo southward, not rare. Here described from three large examples, the largest  $18\frac{1}{2}$  inches long, from Sagami Bay (off Misaki and off Enoshima), and from one about a foot in length from Wakanoura. In all these the number of gill openings is six on each side. The specimen from Wakanoura has the snout very much shorter than either of the others, the outer buccal barbel reaching within half its length of the eye, almost a whole length short in the others. No other important differences appear, and probably this is within the range of individual variation. It is barely probable

that the specimen from Wakanoura, with the short snout, may belong to a distinct species. In general, the example figured by us (from off Enoshima; Collection of U. S. Fish Commission steamer *Albatross*) agrees with Schlegel's plate.

With the species of *Myxine*, this species is known to the Japanese fisherman as *Natunagi*, or slime-eel. The two species are alike in size, color, and habit. *Eptatretus burgeri* may be known by the presence of six gill openings on each side, instead of one, by the very blunt upper lip or tip of snout, and by the paler edges to the fins. The eye is much more distinct than in *Myxine*.

Named for its discoverer, Bürger, who collected for Siebold and Schlegel.

### Family III. MYXINIDÆ.

Body eel-shaped, covered by a thin skin, which is easily detached. Along the lower side, for nearly the whole length of the animal, are two rows of mucous glands, each with an external opening, yielding an abundance of mucus, which renders these animals excessively slimy. No eyes. Brain small, of the normal fish type. Skull little developed, cartilaginous; the flexible notochord inclosed in its sheath and extending from the base of the skull to the end of the tail, representing the spinal column. Mouth round, suctorial, without lips, with a few barbels on each side. Nostril single, large, on the median line above, and at the very front of the head, provided with two pairs of barbels. Teeth strong, a single median one on the roof of the mouth, and two rows on each side of the tongue, which is a powerful organ, with a strong, fibrous tendon moving in a muscular sheath. Alimentary canal a simple, nearly straight tube, without spiral valve; gill sacs placed on each side of the œsophagus, lying directly against its outer walls. The water passes into them by a small pore opening directly from the œsophagus into each sac. It is then passed out by a duct, which continues backward along the outer walls of the sacs to the abdominal wall at the end of the last sac, where all the ducts from one side unite into one, and the water is emptied at the branchial opening on each side of the median line. In close connection with the branchial opening on the left side there is a third opening that leads by a very short duct to the œsophagus, and hence into the branchial sacs, at the times when the supply of water is cut off by the head being buried in the flesh of the animal on which it feeds. Vent close to tip of tail. Ovary single, on the right side. No oviducts; the mature eggs falling into the abdominal cavity and excluded through the peritoneal opening at the side of the vent. Eggs with a horny case, and threads for adhesion. Parasitic animals, burrowing into the bodies of fishes, and found in the cold seas. One genus, with several species, found in most cold seas.

## 3. MYXINE Linnæus.

*Myxine* LINNÆUS, Systema Nature, 10th ed., 1758, p. 650 (*glutinosa*).  
*Gastrobranchus* BLOCH, Ichth., XII, 1797, p. 51, pl. ccccxiii (*cæcus*).  
*Muraenoblenna* LACÉPÈDE, Hist. Nat. Poiss., V, 1803, p. 647 (*olivacea*).  
*Anopsus* RAFINESQUE, Anal. de la Nature, 1815, p. 493 (*olivacea*).

Characters of the genus included above.

(An old name, from *μύξα*, slime.)

## 3. MYXINE GARMANI Jordan and Snyder, new species.

*Myxine australis* GÜNTHER, Challenger Fishes, 1887, p. 267, not type, Hyalonema  
 Ground off Enoshima.

*Myxine* sp. GARMAN, Deep Sea Fishes, 1900, p. 345.

Teeth in upper series ten in number: the anterior three confluent at base but not enlarged, rather narrow and not longer than the next teeth: labrum or tip of snout above narrowly triangular, pointed at tip, resembling the barbels, and scarcely shorter than the barbel standing next: pectoral pores about thirty: nasal barbels well developed, the upper somewhat shorter: buccal barbels prominent, the inner pair short and thick, the lower longer than the rostral barbels. Gill openings moderate, inserted a little before end of first third of body; vent a little before middle of dorsal fin; anal scarcely as deep as dorsal.

Color dark purplish brown or plum color, slightly paler below; barbels pale; dorsal and anal not edged with paler, no pale ridge along back.

Described from three specimens, the largest  $19\frac{1}{2}$  inches long, in fine condition, the others injured, all taken off Misaki, where the species is rather common.

It was first noticed by Dr. Günther who had half a dozen specimens from the Hyalonema grounds off Enoshima, at a depth of 345 fathoms. Dr. Günther identifies these specimens with *Myxine australis* Jenyns, from Patagonia, and further "believes" on rather scanty evidence "that *Heptatremia cirrhatum* of Schlegel (*Eptatretus burgeri*) should be referred to the same species."

As to this Mr. Garman very properly observes: "The results of comparisons of representatives of the genus from other parts of the world are such as to raise doubts concerning the specific identity of the Japanese species with either of the species of *Myxine* from other regions."

The Japanese form is in fact distinct, allied to *M. tridentiger* Garman, from Sandy Point, Patagonia, in its dentition, and to *M. acutifrons* Garman, from the same region, in the form of its labrum, or front of snout.

Named for Samuel Garman, of Harvard University, in recognition of his excellent work on the species of *Myxine*.

## Order HYPEROARTII.

## THE LAMPREYS.

Nasal duct a blind sac, not penetrating the palate. This order is equivalent to the single family *Petromyzonidae*. (*ὕπερρώα*, palate: *ἄρτιος*, complete; i. e., entire.)

## Family IV. PETROMYZONIDÆ.

## (THE LAMPREYS.)

Body eel-shaped, subcylindrical anteriorly, compressed behind; the mouth nearly circular, suctorial, usually armed with horny teeth, or tooth-like tubercles which are simple or multicuspid resting on papillæ; those immediately above and those immediately below the œsophagus more or less specialized; eyes developed in the adult; gill openings 7, arranged in a row along the sides of the "chest;" nostril on top of the head just in front of the eyes; lips present, usually fringed; dorsal fin more or less deeply divided by a notch; the posterior part commonly continuous with the anal around the tail; intestines with a spiral valve; eggs small.

These animals undergo a metamorphosis; the young are usually toothless and have the eyes rudimentary. Separate generic names (*Amniocetes*, *Scolicosoma*, *Chilopterus*) had been applied to these larval forms before it was discovered that they were the normal young of the true lampreys.

The lampreys inhabit rivers of temperate regions. They attach themselves to fishes and feed by scraping off the flesh with their rasp-like teeth. Most of them ascend rivers or brooks at the spawning season, after which very many of the individuals die.

a. Second dorsal continuous with caudal.

b. Supraoral and infraoral laminae with teeth or tooth-like tubercles.

c. Supraoral lamina very large, expanded laterally, forming a crescent-shaped plate with a cusp at either end and rarely a very small median cusp; anterior lingual tooth little developed, its edge crescent-shaped and dentate, the middle denticle enlarged; buccal disk small, the lateral teeth small and never tricuspid; dorsal fins separate or united at base; small lampreys; fluviatile. *Lampetra*, 4.

## 4. LAMPETRA Gray.

*Lampetra* GRAY, Proc. Zool. Soc. London, 1851, p. 235 (*fluvialis*).

Lampreys of small size, with the dorsal fin emarginate, or divided into two parts, the posterior portion continuous with the low anal fin around the tail; supraoral lamina broad, forming a crescentic plate, with a large bluntish cusp at each end, and rarely a very small median cusp; lingual teeth small, with a crescent-shaped dentate edge, the median denticle enlarged; buccal disk small, its teeth few



and never tricuspid. Small lampreys inhabiting the brooks of Europe, Asia, and North America.

- a. Dorsal fin divided into two parts, separate or joined at base only; infraoral lamina with 6 to 8 sharp cusps..... *japonica*, 4
- aa. Dorsal fin distinctly continuous, but with a sharp notch; infraoral lamina with 6 to 7 blunt cusps ..... *mitsukurii*, 5

4. LAMPETRA JAPONICA (Von Martens).

YATSUMEUNAGI (EIGHT-EYED EEL).

*Petromyzon japonicus* MARTENS, Archiv. Naturg., XXXIV, 1868, p. 3; Japan.

*Petromyzon fluvialtilis* ISHIKAWA, Prel. Cat., 1897, p. 63, Yamagata, Niigata, Takata, R. Shimizu, Totomi, Owari, Kioto, Uji in Yamashiro, Lake Biwa at Nagahama in Omi, Hatta, Lampreys of Japan. Rivers of southern Hondo. (Not of Linnaeus.)

Supraoral lamina forming a long, crescentic plate, with a sharp cusp at either end; no median cusp; infraoral lamina with seven (six to eight) sharp cusps, which are nearly equal, except that the outer is much broader than the others; lateral teeth, three on each side, each with two cusps; tongue with nine cusps, the median much the largest; lips fringed; two rows of simple teeth in front of mouth above. Dorsal fins entirely separate, the first not quite half the height of the second, the interspace  $2\frac{1}{5}$  in head;  $2\frac{3}{4}$  in length of first dorsal. Gill openings, 7; head,  $1\frac{1}{10}$  in thorax; snout,  $1\frac{3}{4}$  in head; head, 10 in total length; greatest depth,  $1\frac{2}{5}$  in head. Tail,  $4\frac{1}{4}$  in total length. Blackish; paler below; tail darker; dorsals edged with pale.

Rivers of southern Hondo, north about to Niigata and Sendai, generally common. Here described from a specimen  $18\frac{1}{2}$  inches long from Shinano River in Echigo. Other specimens obtained by us are from near Tokio (infraoral cusps six, the outer more enlarged); one from Noyshiro, six cusps; Noyshiro, eight cusps, the two outer coalescent on either side.

This species is very close to *Lampetra aurea* (Bean), of the Yukon River, and to *Lampetra fluvialtilis* Linnaeus, of the streams of Europe.

Our material is not sufficient to show that it is really different from either or both of these. It is, however, very undesirable to unite nominal species from widely separated regions until identity is actually shown. This species seems to have a higher second dorsal than the European species. From Dr. Hatta's map of the distribution of lampreys in Japan, it is evident that the present species has a much more southerly range than the other. This would indicate that it is not identical with the lamprey of the Yukon. The species is known in Japan as Yatsumeunagi, or Eight-eyed Eel.

*Lampetra crustii* (Dybowski) (Fischfauna des Amurgebietes, 1872, 220), from the mouth of the Amur, is also close to *Lampetra japonica*, but is said to have 19 denticles in a row across the tongue.

## 5. LAMPETRA MITSUKURII (Hatta).

*Petromyzon branchialis* ISHIKAWA, Prel. Cat., 1897, p. 63, Sapporo, Hokkaido.—  
HATTA, Lampreys of Japan, rivers of northern Japan (not of Linnaeus).

*Lampetra mitsukurii* HATTA, Ms. based on *Petromyzon branchialis* Hatta, not of  
Linnaeus.

*Lampetra mitsukurii* JORDAN and SNYDER, Proc. U. S. Nat. Mus., 1900, p. 336 (no  
description; young specimens from Tokio and Lake Biwa referred to by  
error; those belong to *L. japonica*);—JORDAN & SNYDER, Catal. Fish. Japan,  
1901.

Supraoral lamina forming a crescentic plate, shorter than in *L. japonica*, the cusp at either end shorter and more obtuse; infraoral lamina with about six blunt cusps, the outer ones much broader and longer than the others; lateral teeth three on each side, each bicuspid and blunt, two or three rows of simple teeth in front of supraoral lamina; lips fringed.

Dorsal fins connected, the first two-fifths to one-third height of second, the connecting membrane of the two fins about one-third height of first. Head  $1\frac{1}{2}$  in first dorsal, about one-tenth longer than thorax; gill openings, 7; head, 9 in total length; tail, 4; 62 muscular impressions between gill openings and vent.

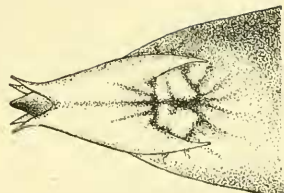
Color bluish-black, the belly white; tip of tail blackish; fins pale, edged with darker.

Rivers of Hokkaido, and Hondo north of Sendai and Niigata, generally common. Here described from eight specimens, one  $5\frac{1}{2}$ , the others 12 to 14 inches in length, obtained from the Ishikari River, at Sapporo in Hokkaido. The smallest one has seven infraoral cusps and the teeth are less developed. It agrees in all other regards with the largest one.

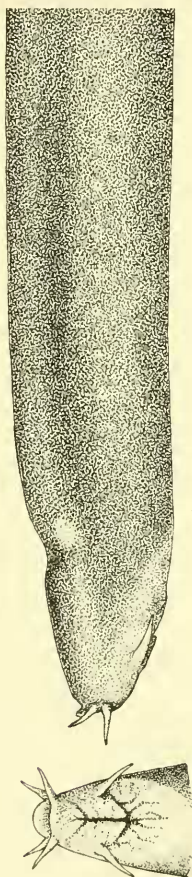
From the lampreys of southern Japan this species is at once distinguished by the united dorsals.

This species is related to *Lampetra wilderi* of the eastern United States, and still more closely to *Lampetra planeri* (Bloch) of Europe. It will require actual comparison of specimens to separate it from the latter, but our experience with other species in widely separated regions shows that it is very hazardous to assume identity of species simply because superficial and noncomparative descriptions indicate no difference. The Japanese species seems to reach a larger size and to have higher fins than the European.

Named for Professor Mitsukuri, of the Imperial University of Japan.



The upper illustration represents an under view of the head of *Myxine garmani*, for description of which see page 731.



EPTATRETUS BURGERI.

FOR EXPLANATION OF PLATE SEE PAGE 729.